

TOA fluxes from MTG/FCI: first results on test data and preparation of the commissioning

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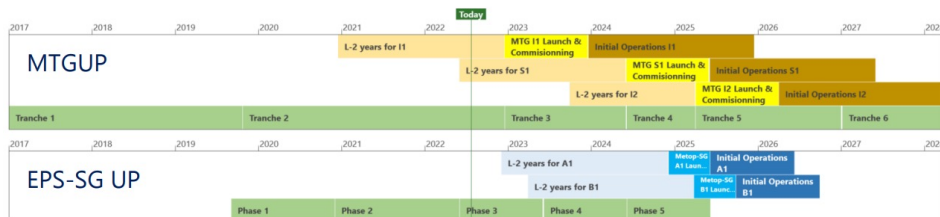
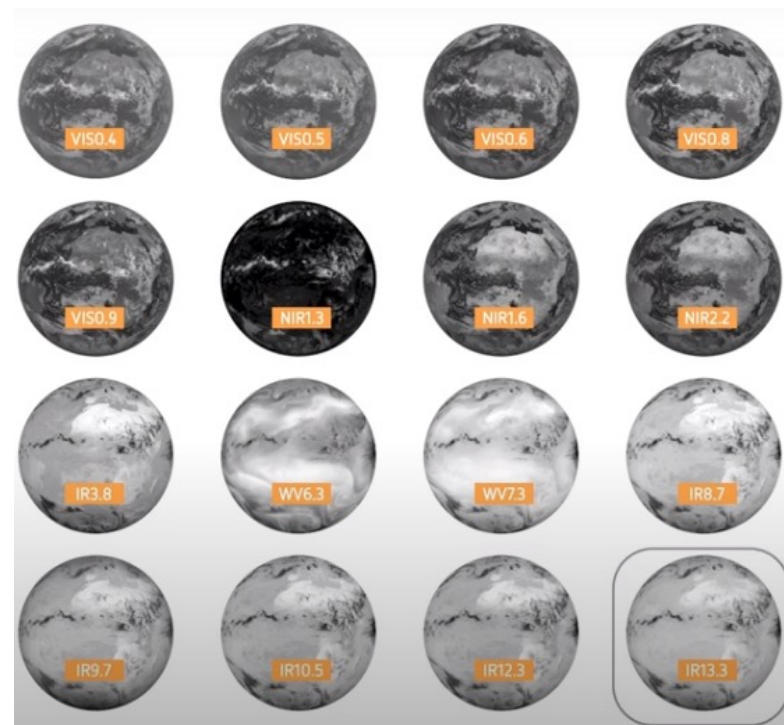
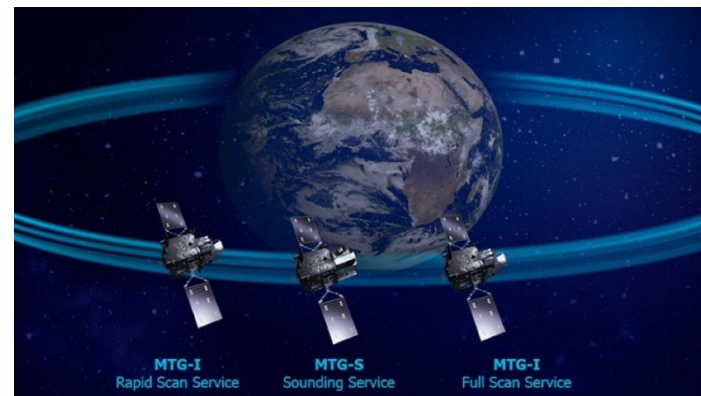
*GERB technical session
Earth Radiation Budget Workshop 2022
MPI-M, Hamburg, 12-14 Oct. 2022.*

- Introduction to MTG
- Rationales for TOA radiation products from MTG/FCI
- Preparation using MTG/FCI test data
- “SEVIRI-heritage channels” products
- “Full channels” products
- Comparison with other state of the art imagers (GOES-16, Himawari-8, VIIRS, MetImage)
- Summary

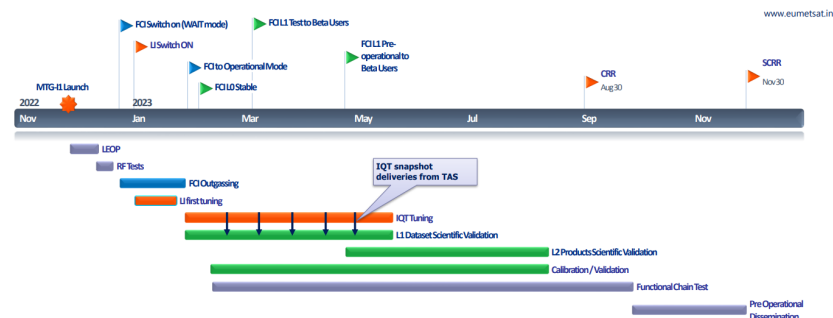
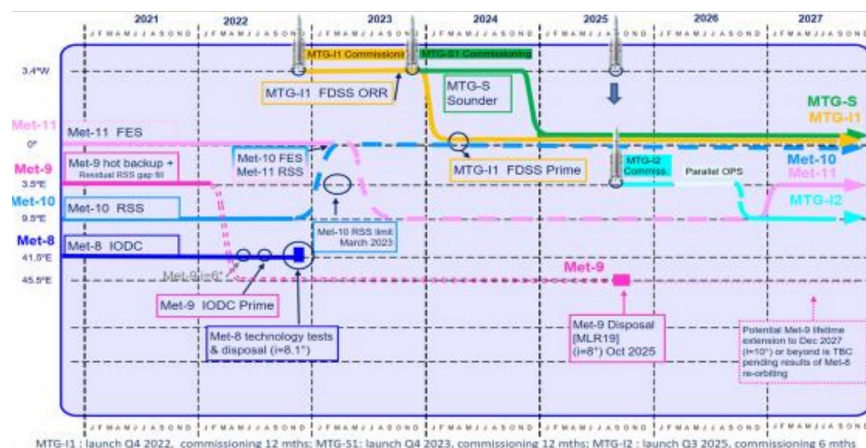


Reference : *Combined Technical Notes: Evaluation report on the homogeneous transition of cloud physical properties from MSG to MTG & Evaluation report on the transition of TOA Radiation components from MSG to MTG, SAF/CM/RMIB/TN/CDOP3/WP2340, version 1.0, date 15.07.2022*

- 2 imager (MTG-I) and 1 sounder (MTG-S)
- Imager : Flexible Combined Imager (FCI)
- Full Disk High Spectral Imagery (FDHSI) : 16 channels @ 2km (thermal) and 1km (solar). (Note : 2 thermal channels also at 1km and 2 solar channels at 0.5 km)
- No GERB mission continuity with BB instrument. It is generally admitted that NB→BB would be accurate enough.
- Calibration : BB and MND (Metallic Neutral Density) filters (+ deep space)



- MTG-I1 launch on 30 Nov. 2022 (or 14 Dec.)
- Commissioning almost 1 year
- First FCI images to users around April 2023
- Pre-operational dissemination on EUMETCast around June 2023
- “Close loop users” with feedback expected from EUMETSAT for Product Validation Review Board (PVRB).
- Switch the operational service end 2023
- Overlap with MSG but MTG-I1 @ 3.5°W and MSG-3 @ 0°W



“SEVIRI Heritage Channels” product:

- Development of a long MSG+MTG record over 2004-present (CM SAF CLAAS-4 activity).

“Full channels” product:

- Continuation of the GERB mission
- Participate to “Geo Ring” TOA products with GOES, Himawari, AGRI, ...
- Participate in ISCCP-NG (e.g. verification of the simulated fluxes profile with TOA observations).
- Synergies with EarthCARE BBR fluxes (e.g. better understanding of the GEO instantaneous flux error due to ADMs).
- (...)

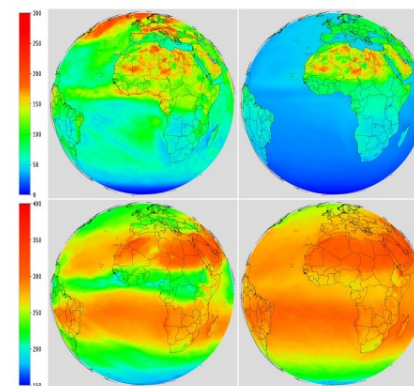


Figure 5: Monthly mean products for June 2010. The upper panels are TRS, lower are TET. Left are all sky fluxes and right is clear sky fluxes. All fluxes are in W/m^2 . The overlaid country borders are obviously not present in the data file.

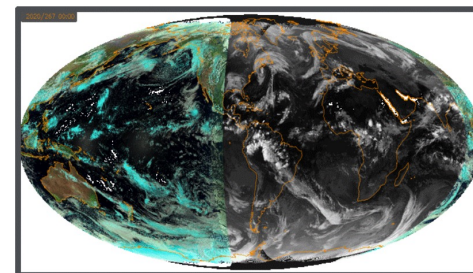
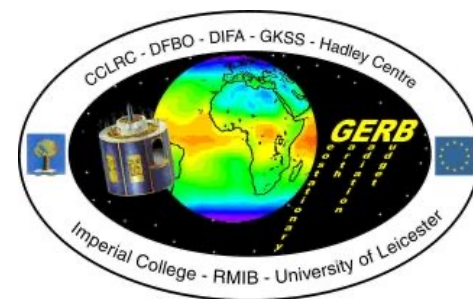
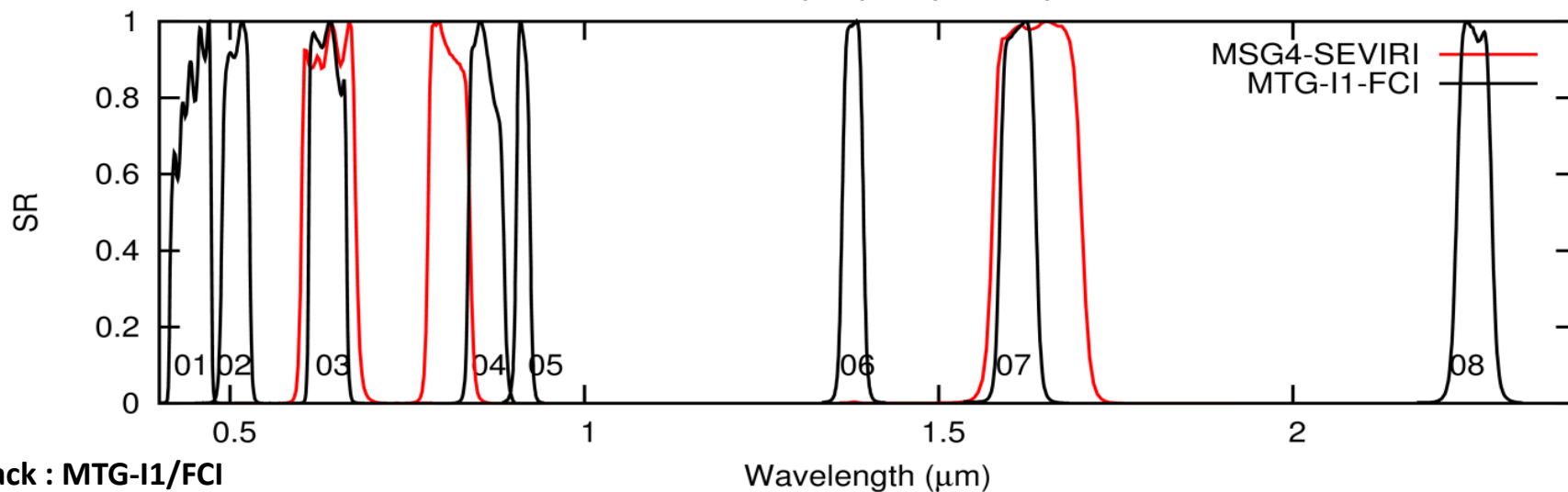


Image made from ISCCP-NG Ltg Data

Spectral Responses : MTG and MSG

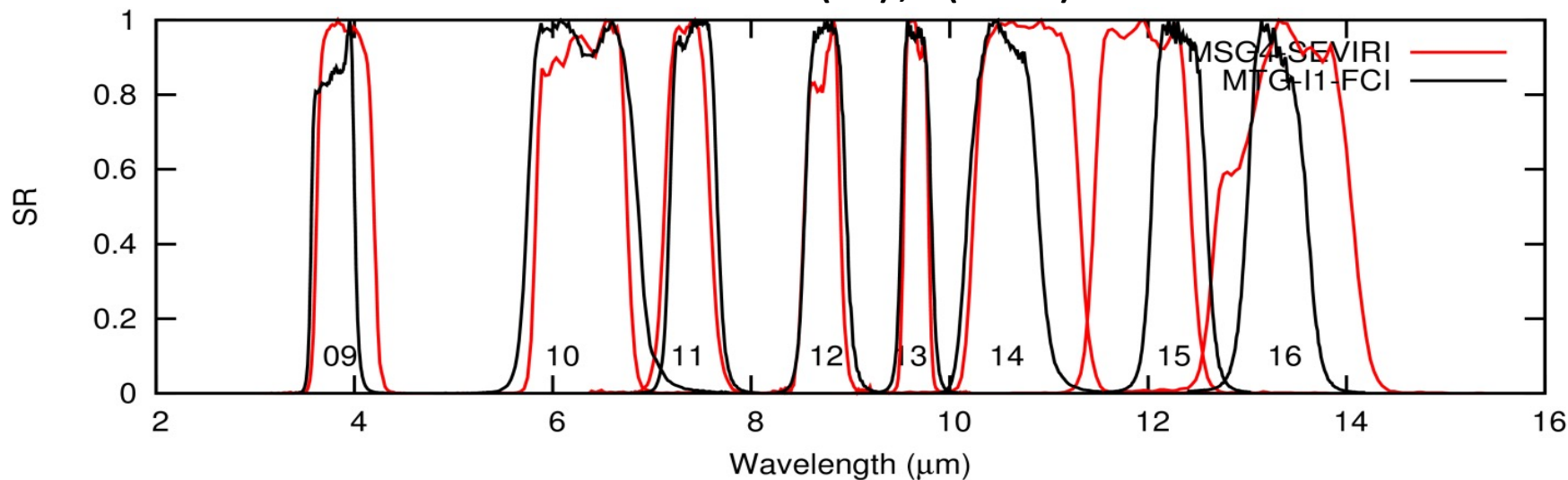
Solar channels : 8 (FCI) , 3 (SEVIRI)



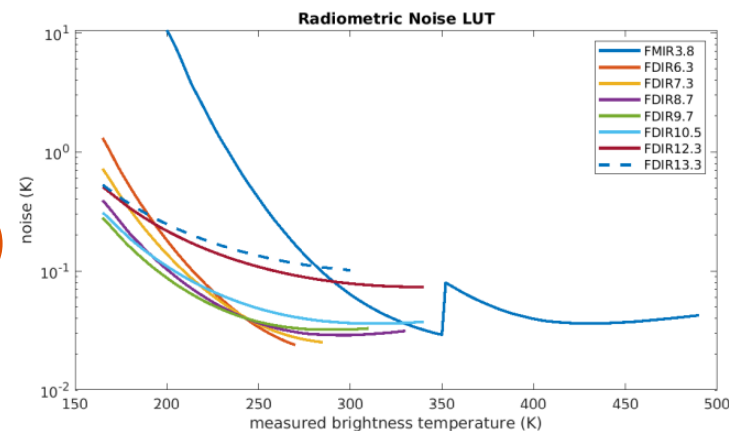
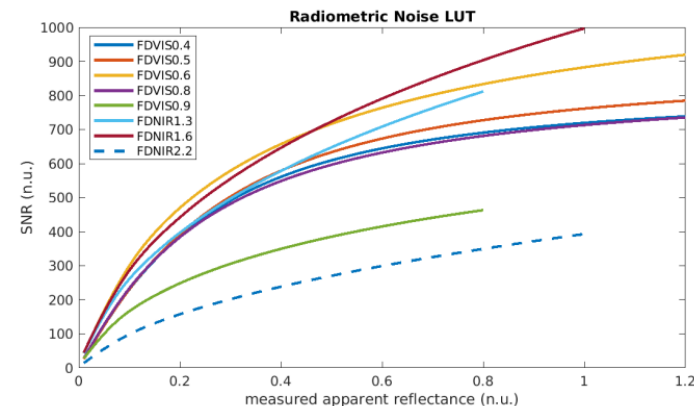
Black : MTG-I1/FCI

Red : MSG4/SEVIRI

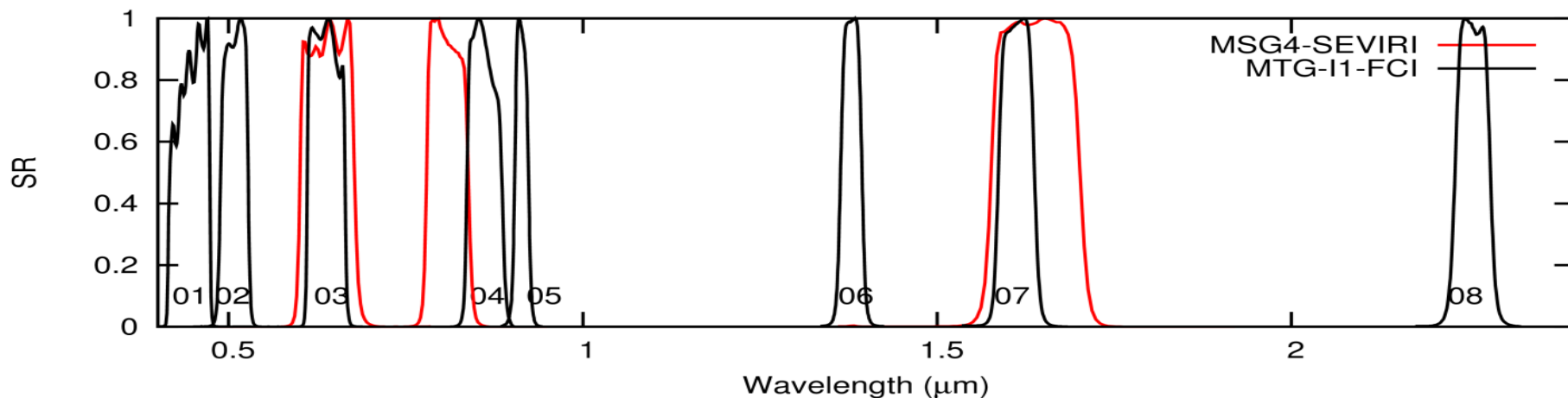
Thermal channels : 8 (FCI) , 8 (SEVIRI)



- MTGTD-360 (released May 2022)
- 24 h of FCI Level 1C FDHSI (day : 20.09.2017)
- Solar /Thermal channels @ 1km / 2km
- Simulated channels that are spectrally representative of the actual MTG FCI instrument
- Based on the latest FCI spectral response functions
- Includes noise
- ECMWF (atm.), CAMS (aerosols), SEVIRI (cloud)
- RTM : ARTDECO / RTTOV for solar/thermal simulations



https://sftp.eumetsat.int/public/folder/UsCVknVOOkSyCdgpMimJNQ/User-Materials/Test-Data/MTG/MTG_FCI_L1C_SpectrallyRepresentative_TD-360_May2022/

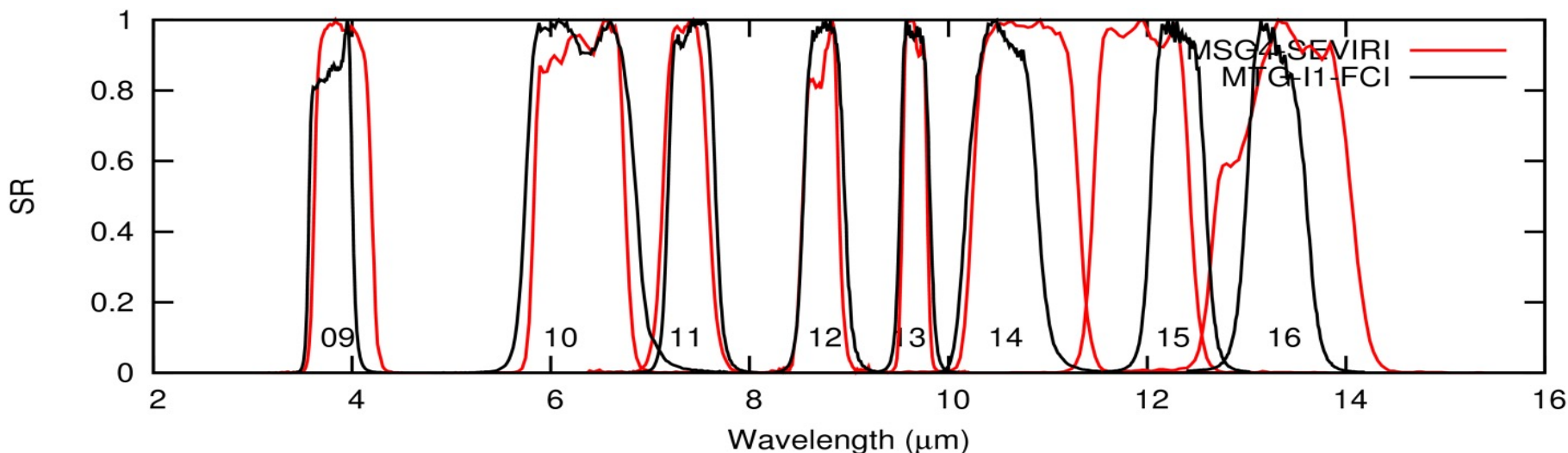


Spectral band adjustments based on RTM simulations (libRadtran):

Regressions for MTG → MSG solar channels	RMSE	(%)
$VIS006 = 0.000236 + 1.005716 * CH03$	0.0021	0.5%
$VIS008 = -0.001942 + 0.067589 * CH02 + 0.735623 * CH04 + 0.240638 * CH05$	0.0080	1.7%
$IR_016 = -0.000813 + 0.026045 * CH05 + 0.991830 * CH07$	0.0052	1.7%

Spectral band adjustments not fully accurate for VIS008 and IR_016:

- Develop/use dedicated NB→BB regressions for MTG/FCI
- Develop empirical relations based on collocated MTG/MSG data

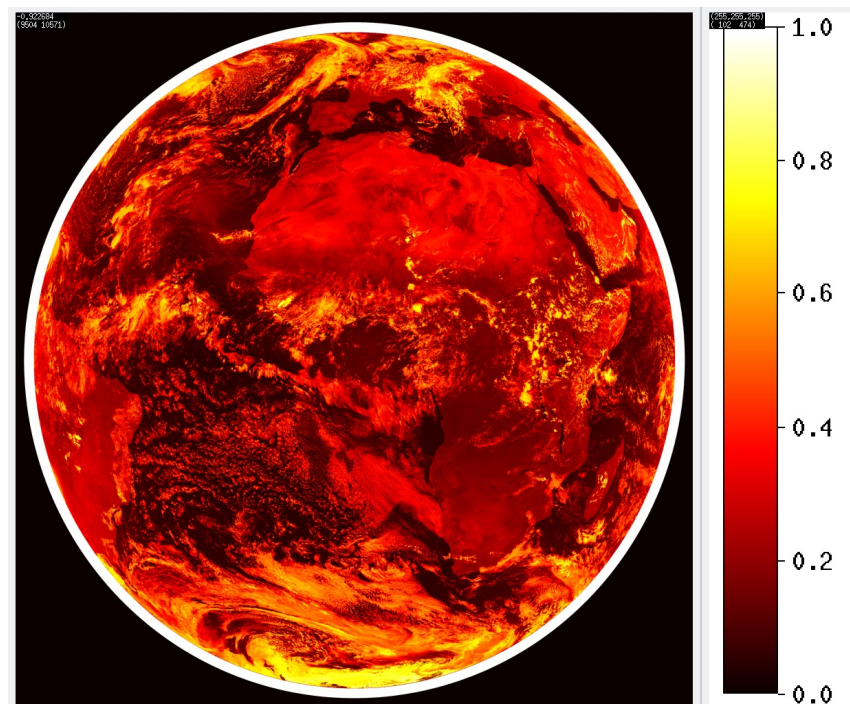


Spectral band adjustments based on RTM simulations (SBDART):

Regressions for MTG → MSG thermal channels	RMSE	(%)
CH09 > 240K : IR_039 = 8.448914 + 0.964314 * CH09	0.6 K	0.22%
CH09 < 240 : IR_039 = 56.269095 + 0.763111 * CH09	2.3 K	1.00%
WV_062 = 1.880384 + 1.041622 * CH10 - 0.051980 * CH11	0.21 K	0.09%
WV_073 = -1.722645 + 0.050784 * CH10 + 1.038748 * CH11 - 0.083994 * CH16	0.17 K	0.07%
IR_087 = 0.245946 + 0.996822 * CH12	0.03 K	0.01%
IR_096 = 0.204206 + 1.012747 * CH13 - 0.014151 * CH14	0.04 K	0.02%
IR_108 = -3.008842 + 0.890533 * CH14 + 0.120727 * CH15	0.14 K	0.06%
IR_120 = 0.111141 + 0.208530 * CH14 + 0.866020 * CH15 - 0.075872 * CH16	0.13 K	0.05%
IR_134 = 19.312592 + 0.909768 * CH16	0.94 K	0.39%

- Based on radiative transfer simulations
- Regression in (bidirectional) reflectance
- Adding 2% noise on the NB reflectances to avoid “overfitting” of the RTM simulations
- NB → BB RMS error of 0.0031 which is 0.9% of the average BB reflectance (0.35)
- Corresponding MSG/SEVIRI RMSE of 4.3%
- Illustration on MTG/FCI test data

BB reflectance (ρ_{BB}) estimated from FCI test data on 20.09.2017 12:00 UTC



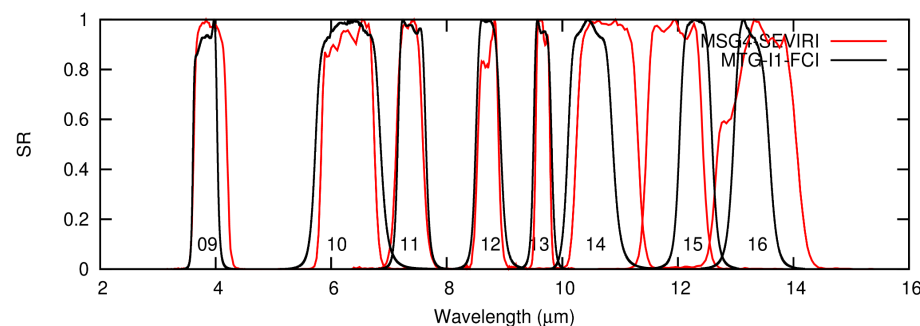
Example for SZA=30°, VZA=30°, RAA=90° :

$$\rho_{BB} = 0.00619 + 0.18980 \rho_{CH01} + 0.11731 \rho_{CH02} + 0.14371 \rho_{CH03} + 0.10182 \rho_{CH04} + 0.21284 \rho_{CH05} + 0.05102 \rho_{CH06} + 0.07835 \rho_{CH07} + 0.03839 \rho_{CH08}$$

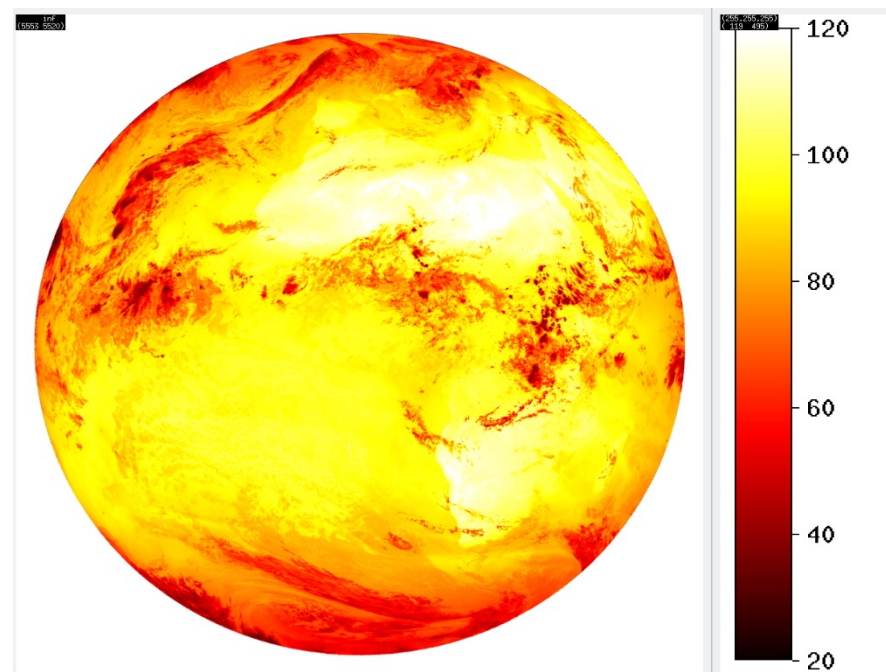
	# solar ch.	No noise	1 st order 5% noise	2 nd order 5% noise
MTG/FCI	8	0.9%	1.0%	0.7%
MSG/SEVIRI	3	5.1%	5.1%	4.3%
GOES16/ABI	6	2.9%	3.0%	2.7%
Himawari-8/AHI	6	3.9%	4.4%	4.1%
SNPP/VIIRS	9	3.6%	4.7%	3.5%
Metop-SG/VII (MetImage)	11	0.8%	0.9%	0.8%

Note : GERB SW channel unfiltering RMS error of ~0.5% (Clerbaux et al., 2008)

- Slightly worse results for MTG/FCI than for MSG/SEVIRI
- This based only on the spectral responses,
- but MTG/FCI might profit for better detectors and calibration process.



BB thermal radiance (L_{th}) estimated from FCI test data on 20.09.2017 12:00 UTC



	RMSE	
	1st order regression	2nd order regression
MSG/SEVIRI	0.84 W/m ² /sr (1.2%)	0.45 W/m ² /sr (0.65%)
MSG/SEVIRI with IR_O39	0.77 W/m ² /sr (1.1%)	0.45 W/m ² /sr (0.65%)
MTG/FCI	0.92 W/m ² /sr (1.3%)	0.51 W/m ² /sr (0.74%)
MTG/FCI with CH09	0.84 W/m ² /sr (1.2%)	0.51 W/m ² /sr (0.74%)

	# solar ch.	No noise	1 st order 5% noise	2 nd order 5% noise
MTG/FCI	7	1.3%	1.3%	0.8%
MSG/SEVIRI	7	1.2%	1.2%	0.7%
GOES16/ABI	9	1.3%	1.3%	0.7%
Himawari-8/AHI	9	1.3%	1.3%	0.7%
SNPP/VIIRS	4	2.9%	3.9%	3.2%
Metop-SG/VII (MetImage)	6	1.4%	1.4%	1.1%

- **Similar results for the different imagers (including SEVIRI)**
- **Except VIIRS (no H₂O channels)**

- **On-going preparation to MTG**
- **Continuation of SEVIRI in CM SAF CLAAS CDR :**
 - No significant problem expected for the OLR
 - Significant SR differences for visible $0.8\mu\text{m}$ and near infrared $1.6\mu\text{m}$ channels:
 - More effort in SBAF (e.g. empirical correction)
 - Otherwise develop dedicated NB \rightarrow BB relations for FCI and check consistency with SEVIRI using overlap data.
- **Plan to derive “full channel” GERB-like from MTG/FCI soon after launch (but as *best effort* basis) :**
 - Reflected solar flux (RSF) from MTG/FCI looks very promising (NB \rightarrow BB error $\sim 1\%$)
 - MTG/FCI OLR not expected to improve with respect to MSG/SEVIRI OLR
 - 2 steps approach : (1) start with theoretical regressions, (2) derive empirical relations (e.g. with GERB)